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REMOTE SYSTEM FOR MONITORING AND CONTROL OF CONTROLLED AREA OF NUCLEAR INSTALLATION

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ABSTRACT

The maintenance activities in controlled areas of nuclear facilities require adequate planning and control so that these activities do not cause to the worker an undue exposure to radioactivity. For maximum safety of workers who work in these places, there are standards that determine the maximum radiation dose that a worker can receive. From this context, the objective of this research is to develop a remote system that shows remotely the maintenance tasks being carried out in this work environment; monitors information provided by radiation monitoring devices installed at workplace; tracks the time to carry out scheduled maintenance, reporting alarm if this time is exceeded or not. The system has video camera, radiation monitoring device, interface card to transmit data via ethernet and graphical user interface, developed using the LABVIEW application. The principal objective is to improve the safety and to preserve the worker's health.

1. INTRODUCTION

According to the considerable increase of nuclear activities in Brazil and expanding the use of nuclear techniques in the fields of industry, agriculture, medicine, among others, this research addresses issues extremely important to all who work in areas of exposure to ionizing radiation. To improve safety conditions at nuclear facilities, National Commission of Nuclear Energy (CNEN) has a team of experts in radiation protection and employee's safety. Its main mission is to enforce the rules and safe practices in carrying out activities that involve the handling of radioactive materials and exposure to ionizing radiation.

During shutdowns of a nuclear reactor, maintenance activities are performed inside the containment of the nuclear plant. Maintenance activities require adequate planning and control of time of the workers that stay in the workplace. Nuclear standards determine the maximum radiation dose that a worker can receive to perform tasks in workplaces with a high level of radiation. However, to control and to monitor accurately this time is not an easy task to be performed.

A standard is a set of rules, conditions or requirements that define terms; classify and specify components; specify materials, performance or operations; delineate procedures; define measurements of quantity or quality of materials, products, systems, services or practices [1]. Taking into account the rules and standards established by CNEN, and on the hypothesis that initiatives should be developed to encourage technological capabilities, safety, environmental preservation, and thus preserving the health of the individual, it is necessary to develop support systems that monitor the activities carry out within the nuclear installations. The standards, as already mentioned, prescribe strictly the limitation of exposure time, so that the workers subject to occupational exposure does not receive doses above the tolerance limits established [2].

The objective of this research to develop a remote system that shows remotely the maintenance tasks being carried out in this work environment; monitors information provided by radiation monitoring devices installed at workplace; tracks the time to carry out scheduled maintenance, reporting alarm if this time is exceeded or not. The system has video camera, radiation monitoring device, interface card to transmit data via ethernet and graphical user interface, developed using the Labview application.

2. METHODOLOGICAL FRAMEWORK

The principal objective of the methodological framework is to show an approach to develop a remote system used to monitor the maintenance activities carry out within nuclear installations (Fig. 1).

The first phase is related to literature review. The second level concerns functions analysis. It identifies the functions that must be performed to satisfy the goals and objectives of the equipment mission. It aims to identify the process, the controls functions and their functional interrelationships [3]. Functional flow analysis was the technique used to identify the sequence of functions that had been chosen to be performed by the users and by the equipment automatic control.

The third level concerns the functions allocation. It is the process of assigning responsibility for the accomplishment of the functions to human or to automatic systems or to a combination of the two. The allocation is done to determine what is required to perform the functions. Using the results of the functions analysis, responsibility is allocated in a way to ensure overall accomplishment of the functions.

The fourth level is related to task analysis. It is the process of assignment actions to the humans. The hierarchical task analysis was developed to describe the tasks to be performed by the users.

The next level concerns the implementation phase. The hardware design and the software logic of the equipment are developed. It led to the functional design of the equipment. In the implementation phase, the logical structure designed was taken to a specific programming language. The integration between the hardware and software design and the conversion of this integration into physical equipment are carried out.

The last level is related to test phase. Tests at laboratory are performed to ensure that equipment complies with the requirements determined in the initial phase.

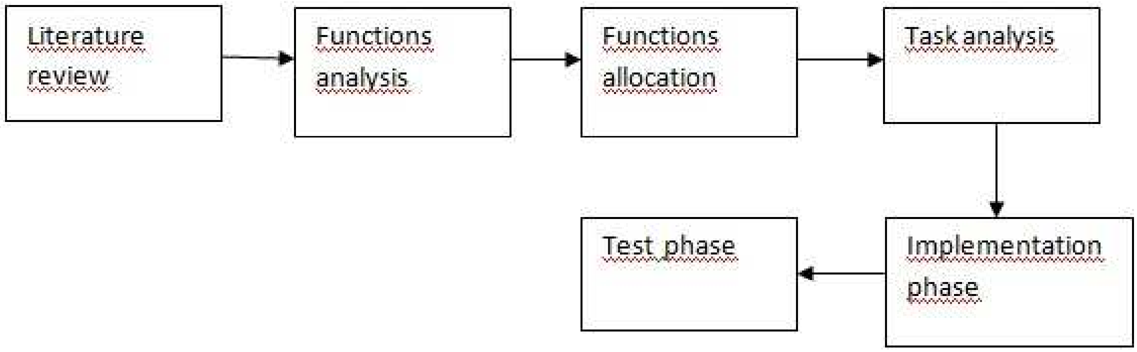

Figure 1. Methodological framework

3. SYSTEM IMPLEMENTATION

The system consists of a video camera, radiation monitor, interface card for transmitting data through the Ethernet network and graphic interface installed on a desktop computer located in the main control room of a nuclear reactor. Video cameras allow, through a graphical interface, view of the workplace, while technicians of the installation are performing maintenance tasks scheduled. Alarm levels are presented through a graphical interface (LabVIEW), on desktop computers. Thus, once the technician enters the workplace, the camera is activated and sends, via the network, when necessary, the following information: time; images of the workplace; an alarm of attention (technician entered the room); maximum length of stay in the workplace; alarm if the maximum length of stay has expired.

In the radiation monitor MRA 7027 [4] developed in the Instrumentation Service (SEINS) of the Nuclear Engineering Institute (IEN) was included and incorporating, in its hardware, a kit which consists of a linear voltage regulator (TPS76333), two components SN74LVC1T45 (transmitter/receiver of digital signal of one bit and two voltage inputs) and network interface (Digi Connect ME). This kit was assembled and integrated with a video camera and operator interfaces through LabVIEW. The Fig. 2 shows the system diagram.

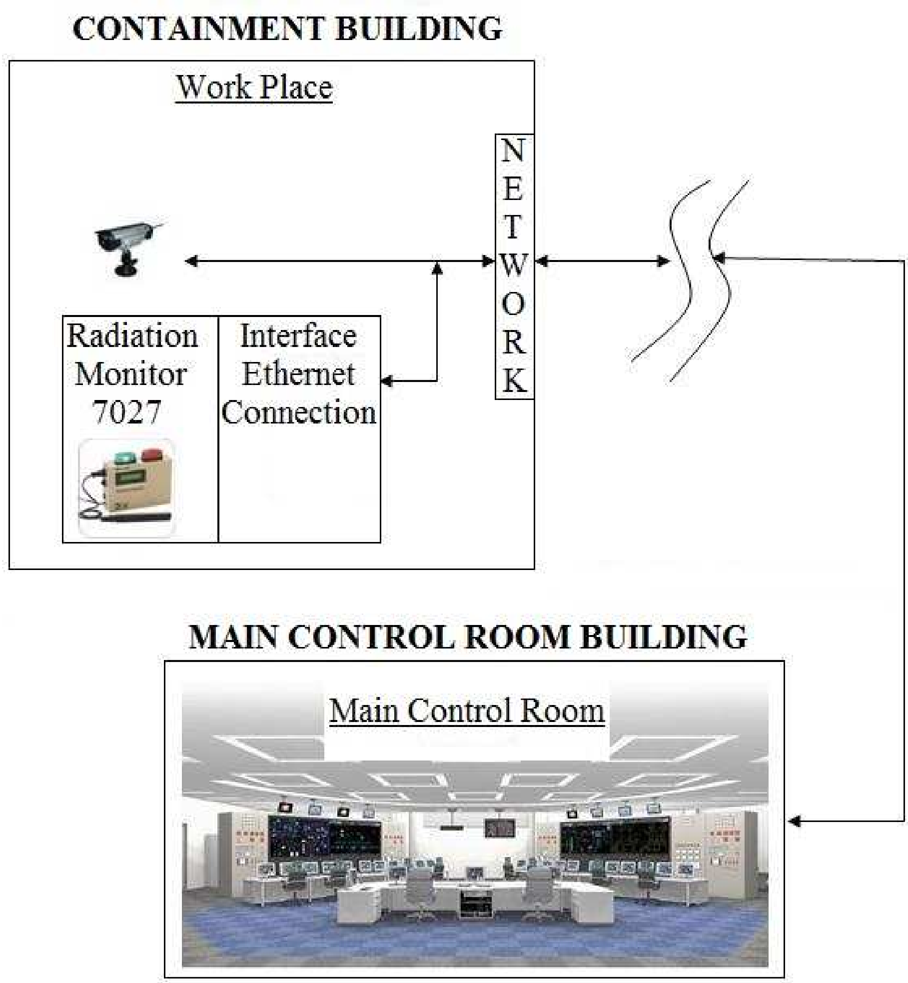

Figure 2. The System diagram

3.1. The Hardware and Software Description

As shown on the system diagram, the control room can communicate remotely with the workplace via Ethernet (TCP/IP). For this, a circuit board was developed and integrated to the radiation monitor with a device called the Digi Connect ME, developed by Digi International. This device type provides Ethernet connectivity for industrial equipment, offering a customized, optimized, low cost and high performance solution [5]. This circuit board with the Digi Connect ME, allows this device to provide a specified operating voltage (3.3V). For this, the board has a linear voltage regulator (TPS76333) which receives a 5V voltage provided by the circuit of the MRA 7027 and converts it to 3.3V.

As this device works with 3.3V, logic levels of the serial communication signals (TX and RX) with the MRA 7027 must be within these limits. So it is necessary to use the component SN74LVC1T45 (Single-Bit Dual-Supply Bus Transceiver). With each input connected to a voltage (5V and 3.3V), it allows the transmission/reception of serial communication signals from the MRA 7027 with the Digi Connect ME device, adjusting the voltage level of the digital signal that is supplied to each device for its specified operating voltage. This was developed because it is not possible to connect the digital signal with the logic level 1 of the MRA 7027 (5V) to the input of the Digi Connect ME, as it works to 3.3V.

The circuit uses two components SN74LVC1T45: one for transmission and one for reception of signals. The port DIR of this device sets the direction that will be used at each moment. In the case of this circuit, a fixed direction was kept: one for transmission and one for reception of signals. When there is a high signal in DIR, one of these devices works toward the MRA 7027 to the Digi Connect ME. When there is a low signal in DIR, the other device works in the opposite direction. Therefore, the communication can be performed between the MRA 7027 and the Digi Connect ME.

Aiming at greater efficiency and flexibility to develop the project, the program LabVIEW 8.5 was chosen [6]. According to National Instruments Corporation, LabVIEW has an interface with the most frequently used programs in the world of programming and a perspective of integration of other software. LabVIEW is a graphical programming language that uses icons instead of lines of text to create applications. In contrast to the language of text-based programming, where instructions determine program execution, LabVIEW uses data flow programming, where the flow of data determines execution. Using LabVIEW 8.5, it was possible to develop software that simulates the monitoring and control desired for this project.

As inputs for the test phase of the system, numerical values were used to simulate the radiation chart, limit control of accumulated dose, time recording and motion detection sensitivity. A button was also used to simulate the radiation rate, another to activate the motion detection to start recording and another one to exit the program. To simulate the recognition of a person in the work room, a text box with the options of the names of workers who have permission to enter this room was used as input. As outputs of the system, a graphical indicator and a numeric display were used for the rate of radiation. A video acquisition was also used to simulate a video camera used for the monitoring and the recording the video of this work room. Numerical box was used to show the time that the technician is in the room, and also, some LEDs to inform what the system is reading. In this case, a LED indicates that the dose limit is exceeded, another indicates whether there is movement in the room and the other one whether the video recording is being made. On the Fig. 3, the flowchart used to develop the program can be observed.

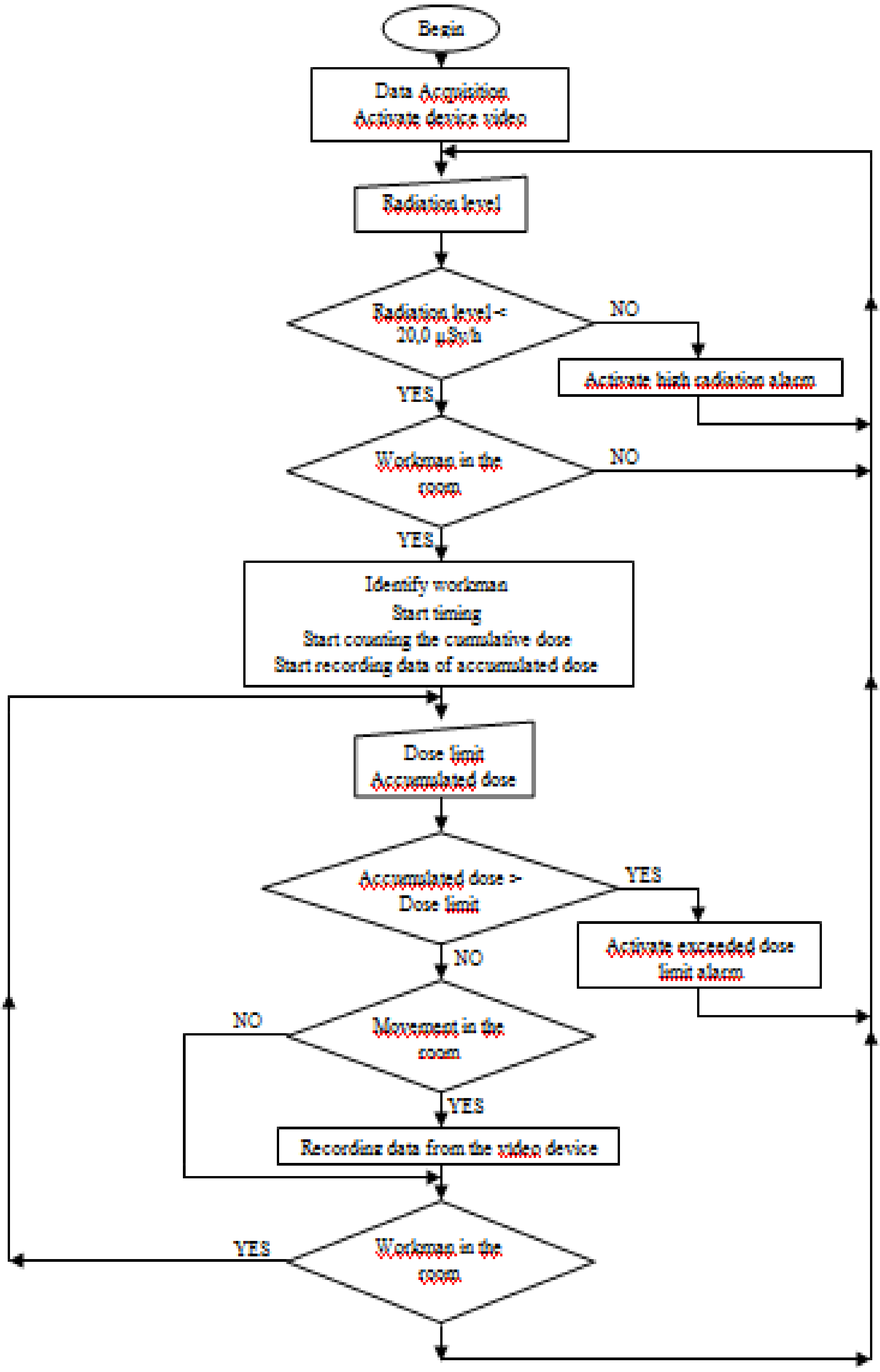

Figure 3. Flowchart created for developing the program in LabVIEW 8.5

Fig. 4 shows one of structure developed using the LABVIEW 8.5.

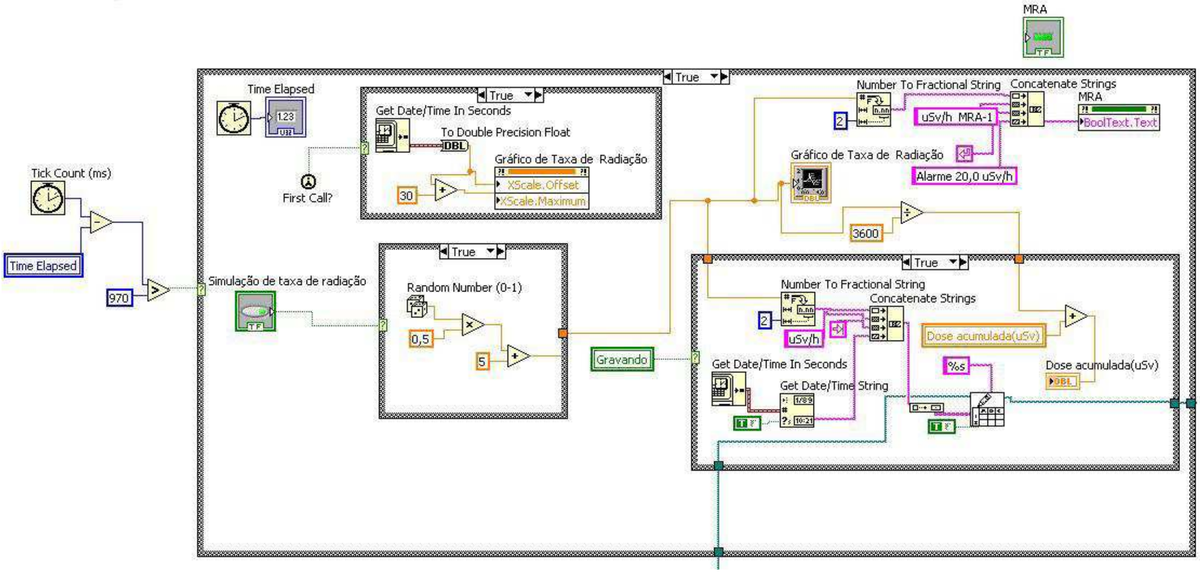

Figure 4. Structure developed using the LABVIEW 8,5

4. RESULTS

Fig. 5 represents the entry of an authorized worker in the controlled area. The system inputs are: the text box "Worker Identified"; the numerical box " Minimum Recording Time (s)"; and the "Sensitivity of Motion Detection". The simulation inputs are: worker was called "Daniel"; the minimum recording time was set to 15 seconds; sensitivity of motion detection was 0.2.

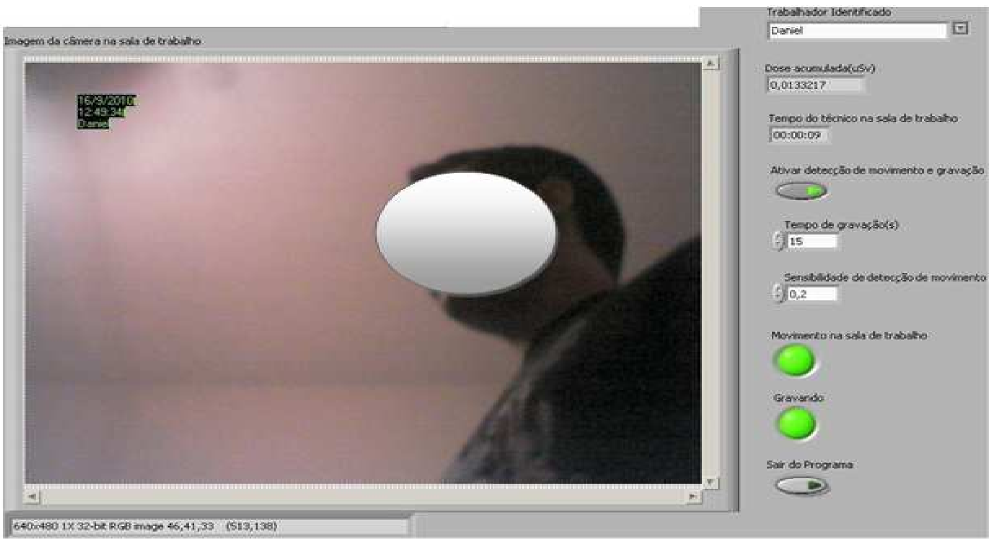

Figure 5. The entry of an authorized worker in the controlled area

Upon entry of the worker, it was possible to simulate the activation of motion detection and observe this movement through the LED called "Movement in the work room". It was possible to get the rate cumulative dose; the time that the worker remained in the room; the video file with the camera image; the date, time and name of worker.

5. CONCLUSIONS

As mentioned in the introduction, the objective of this research was to develop a system that improves the safety conditions at nuclear facilities, aiming issues extremely important to all who work in this kind of controlled areas. The implementation of a video camera to monitor the worker during maintenance operations together with a radiation monitor to control (monitor) the levels of radiation in controlled areas of nuclear facilities was proposed. Taking into account the standards that determine the maximum radiation dose that a worker can receives, when performing tasks in areas that have a high level of radiation, a program that performs the calculation of the accumulated dose to workers in a certain period time was developed. Through this program, if the maximum permitted dose of radiation is reached, the worker can realize this condition and leave the place safely, because the program triggers audible and visual alarms, those warn of the danger of contamination. To be effective in controlling these radioactive areas, the visual data observed by the video camera are recorded on video files, and thus can be viewed at any time after the completion of maintenance tasks. Furthermore, times, dates and accumulated doses by the worker may also be observed because this information is stored in text files with the names of workers.

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